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THE RESTORATION OF DRIED TISSUES, WITH ESPECIAL REFERENCE TO HUMAN REMAINS

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I. — PRELIMINARY EXPERIMENTS

Two or three years ago, while engaged in the preparation of embryonic skeletons after the Schultze method, I was struck with the rapidity with which the specimens, after the preliminary shrinking in alcohol, reassumed their normal size and shape when put into the 3% solution of caustic potash. This led naturally to the question whether the last-named fluid might exert a similar influence upon a tissue deprived of its water by simply drying in the air, and I was thus led to drop into a jar of potash solution a very dry and flattened specimen of a frog, which had been for some months on my desk. This simple experiment was performed one night while I was leaving the laboratory and appeared of so little importance that I had for the moment quite forgotten the incident when on my return the following morning I found what seemed at first a perfectly normal frog floating in a natural attitude upon the surface of the liquid. In the dried condition it had been impossible to determine the species of the specimen, and in fact I had supposed it to be not a frog at all, but a toad; yet after the restoration, every external marking was distinct, and even the colors were in part restored, showing it at once to be *Rana clamitans*. From this time on the specimen continued to imbibe the liquid until within a few more hours it appeared slightly abnormal. The skin was smooth and tense, especially over fleshy regions like the thigh, thus suggesting that the muscles absorbed the liquid more greedily than did the other tissues. To check this action, the frog was then thrown into water, a procedure which proved disastrous, since the bloating, instead of being checked, appeared to be accelerated, until finally the skin over the much-distended thighs burst outward by longitudinal rents, from which the muscles protruded as semi-transparent, almost gelatinous masses. Whether the bursting was due to the use of the water, or whether the potash was removed too late to check the process already far under way, I cannot state definitely, but later experiments with all sorts of dried tissues have given me the impression that the former is the case, and that, after the potash solution has exhausted its power, an immersion in water will cause further distension.

This experiment with the frog was followed, as occasion offered, by similar ones performed upon other frogs, a turtle, an earthworm and a few other invertebrate specimens, of which some had been dried in the sun when fresh, while the rest were preserved material from which the alcohol had evaporated, and in all cases the results were exceedingly interesting and furnished specimens of actual value for many lines of investigation. The frogs and the turtle permitted careful dissection, and most of the organs were of normal or nearly normal appearance, the nerves being especially good, thus suggesting the employment of some method of desiccation for the preservation of specimens obtained during expeditions in regions where the employment of the ordinary preservatives is impracticable.

In connection with these experiments the thought naturally occurred to me that this method might also be applicable to some or all of the various forms of dried human remains, even to those of considerable antiquity, since after desiccation is once complete the lapse of time would cause but little further change, and the success of such an experiment would depend mainly on the amount of tissue that had resisted decay before the completion of the drying process more than on the actual age of the mummy.

Through the kindness of Prof. F. W. Putman of the Peabody Museum at Cambridge, Mass., I was supplied with a little preliminary material with which to make a test, since which, both from him and from his former associate, Dr Aleš Hrdlička, then of the American Museum of Natural History, New York, and now of the United States National Museum, I have received a most liberal supply of human remains, illustrating various methods of treatment, and especially well fitted to show the capabilities of the method. I wish to take this opportunity of expressing to them my gratitude for their kindness and practical interest in the matter. I wish also to acknowledge my indebtedness to the other teachers in my department, who have interested themselves in the work, and have furnished me valuable assistance, both in the practical treatment of the material, the microscopic investigation, and in the taking of the photographs which illustrate this article.

I can best set forth the results of these various experiments in the form of a report, taking up the cases in the order of treatment; but before attempting this, I will present a description of the method as it became elaborated during the progress of the work.

II.—The Method

1. The essential reagent is caustic potash, applied in a solution of 1–3%. The dried object is placed at once in a tank of this fluid and held beneath the surface for a few moments, until the entire surface becomes wet. At first the specimen will float on the surface, but as it imbibes more and more of the fluid it will gradually sink. Within a short time, even in a few minutes, the liquid will become so dark-colored that the specimens cannot be readily seen, and it will be better to change the fluid. For a very brittle object 1% solution may first be used, followed after a few hours by 2–3% solution. While in the potash the object should be carefully watched, and should be removed when it threatens to fall in pieces. A certain amount of local disintegration, however, is to be expected, corresponding to places which had begun to decay before the drying process was completed. Those soft places, when the tissue becomes lost in potash, often appear in the dried condition as darker areas; for example, the left cheek of the woman mummy which dissolved under treatment and left the malar bone exposed (compare pl. II, 1, 2). The time in which an object should remain in potash varies, but may be given as between 12 and 48

hours, and it is well to remember that the caution which one naturally feels when treating a rare and valuable object impels one to remove it too soon rather than to leave it too long. In the former cases the features do not acquire their full size, and, in the latter, essential parts are in danger of becoming lost.

2. Upon removal from the potash solution the specimen should be placed in water for some time. This fluid appears to have a tendency to still further increase the swelling, but as it also hastens the maceration of the soft parts, it should be used with caution.

3. All expansion and maceration may be checked, and the parts left permanently in a given condition, by placing the specimen in a three percent solution of formalin, in which it is to remain indefinitely for permanent preservation. Since no further change can subsequently be produced in material once fixed and hardened in formalin, care must be taken that the desired increase in bulk be obtained before immersion in it.

4. If, as usually happens, certain parts are not sufficiently softened and enlarged at a time when the rest threatens to become too soft, the object may be removed from the potash and covered with absorbent cotton, which may be soaked locally in the fluid demanded. Thus the soft parts may be covered with cotton soaked in water, or even formalin, while harder portions may be still subjected to the action of the potash, applied in the same way. In addition to this method, potash may be applied to a refractory part by means of injection with an hypodermic needle. Occasionally glycerin or a mixture of glycerin and potash applied in the same way may be found of value.

III. — REPORT OF EXPERIMENTS

1. RIGHT THUMB OF A PERUVIAN MUMMY. (PEABODY MUSEUM.)

This was the first human material experimented on, and had been torn from a hand in such a way as to include the metacarpal, but was broken in two pieces at the metacarpo-phalangeal articulation. There was but little integument remaining, and the bones were completely bare over extensive areas, but upon the metacarpal there still hung a piece of the web between thumb and index, and from the proximal end of the specimen there protruded several dried cords which eventually proved to be the tendons of the several extensor muscles of the thumb (*ext. primi internod. poll.* and *ext. secund. internod. poll.*).

After the treatment the portions of integument still intact were of about the usual thickness and were otherwise quite as when fresh; the portion covering the dorsum of the basal phalanx showed the characteristic pits for the hair, and the inner portion, especially upon the web, showed the epidermic ridges of the palmar surface. Unfortunately the integument covering the ball of the thumb had been entirely wanting in the dried specimen, so that there was no opportunity to study the apical pattern ("thumb-mark").

Aside from these normal appearances there were seen, scattered irregularly over the surface of the skin, a large number of minute whitish granules which correspond to nothing in the normal integument. A small portion of the integument, including some of these, was then imbedded in paraffin, sectioned with the microtome and stained in the usual ways (carmine, hæmatoxylin, various anilines), and the sections, when examined under the microscope, showed the granules to be minute bacterial foci, surrounded by walls of connective tissue, and were thus plainly pathological and referable to some skin disease, probably the illness to which the subject had succumbed. In the fresh state these granules had evidently been level with the outer surface of the skin, but owing either to decay or to weathering the epidermis had disappeared, leaving these foci projecting above the cutis by about the usual thickness of the missing layer.[1] Aside from these objects the sections showed clearly that the only tissue remaining was the connective tissue, but, since this forms a mold for every other tissue, the outlines of the various structures were well preserved. The blood-vessels were especially clear; the muscle fibers were marked by the sarcolemma, but showed no striations; the cutaneous nerves were clearly seen, but in cross-section they showed merely the network formed by the neurilemma of each fiber, and lacked both the medullary sheath and the axis cylinder. Beneath the cutis were seen the outlines of fat cells in masses, but as these were not quite spherical but somewhat flattened from without inward, it suggested that the restoration had not been complete, and that in life the soft parts were a little fuller than in the specimen at present.

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[1] The slides containing sections of the foci have been sent to the Army Medical Museum for examination, but no report has been furnished as yet.

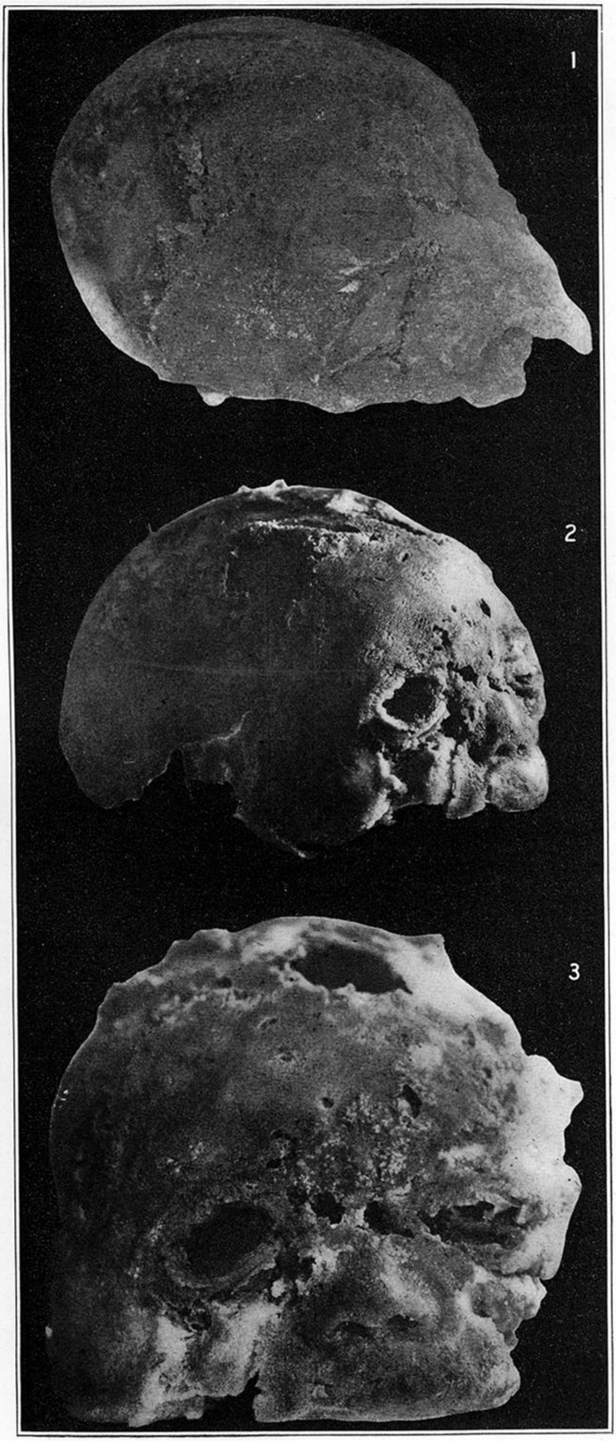
While searching for material for microscopic study, one or two minute pieces of a brownish substance were found, apparently within the tissues. These appeared under the microscope to be bits of cork or bast, from the inner bark of some tree, thus suggesting the use of bark for its tannin during the process of embalming; however, the pieces were too uncertain in location to enable one to draw a safe conclusion, and may well have been adventitious.

2. TWO INFANT HEADS FROM THE CLIFF-DWELLINGS OF SOUTHERN UTAH. (AMER. MUS. NAT. HIST.)

These heads were of infants of the same age, that of about a year. They had the same general color and appearance and had evidently been merely sun-dried in the rarified mountain air, as was the case with all the Cliff-dweller material experimented with.

The soft parts had been preserved in certain regions only, while in others the bones were entirely bare. The best preserved one, designated in my notes as A, showed a nearly flat surface of dried skin over the entire face, featureless, save for the indications of eyes and eye-sockets (pl. 1, 1). No nose was visible, the part in the photograph which resembles that organ being the edge of the upper lip. The lower jaw was without flesh. Upon the side of the face were a few easily removable bits of skin bearing hair, which was that of some animal, as seen under the microscope, and were evidently the remains of a skin in which the body had once been wrapped.

After treatment, Head A presented the appearance shown in plate 1 (2, 3). The nose, of which no trace could be seen in the dried specimen, was well restored, and this, as well as the upper lip, exhibited the characteristic infantile type. The cheeks showed a large amount of yellowish-white fat, and the skin, especially about the forehead, appeared perforated with wormholes. In color the skin was a light yellowish-brown, with frequent localized discolorations, and, although it would be hardly safe to maintain that this



HEAD OF CLIFF-DWELLER INFANT, SHOWING EFFECT OF TREATMENT

1, In dried condition. 2 and 3, The same after restoration. (Photographed from the object.)

method of restoration has the power of restoring the original color, yet the rich brown color of the Peruvian specimens (1 and 4), the light yellowish-brown of the infants, and the brownish-red of the adult "Basket people" seem to approximate in each case one's idea of the original color. One eyelid in this specimen was well brought out and showed well-marked Meibomian glands upon its inner surface. When sectioned, the molds of these glands were definitely shown in the connective tissue, which outlined each lobule, but as in the other cases noted, all epithelial tissue had been lost.

Head B proved of little interest except that the scalp was covered with the crust often seen in neglected infants, "scald-head" (eczema). This specimen, when in the dried state, had shown curious excrescences upon either cheek which may have been of pathological significance, but yielded no especial results after restoration. Microscopic sections taken in various directions showed them merely as rather porous masses without special structure. They may, indeed, have been nothing more than the fat of the cheeks pressed upward by bandaging, but they did not show a trace of the actual fat so abundant in Head A.

3. BODY OF ONE OF THE ABOVE INFANTS

This little specimen was very much flattened, being hardly more than a centimeter thick in any place. It had evidently lain upon its back and right side, as these regions had lost the soft parts, apparently through decay, so that the bones were completely exposed. The most interesting point in this specimen was that, when subjected to the usual treatment, much of it dissolved into a soft, almost jelly-like substance of a dark-brown color, indicative of the advanced state of decay into which these parts had fallen before the drying process had been completed.

The same result has since been seen locally in other sun-dried remains, and such places are indicated in dry specimens by a dark-brown color. In this case the only parts rescued from this destruction were the skin of the abdomen, which had evidently remained uppermost, and the legs (the arms had been lost). These latter came out very well, although the fat, which had once been very abundant, was less amenable to treatment than other tissues, and retained in a measure the creases and other forms which it had assumed when drying. The feet were very successfully restored, and it was noticeable that the four lesser toes were of approximately the same size.

Accompanying this body was a large piece of animal skin covered with hair similar to that upon the fragment found on the face of Head A. This, when restored, did not come out to the full thickness and consistency of fresh integument, but remained thinner and firmer, and had evidently been subjected to some tanning process.

4. HEAD OF YOUNG ADULT PERUVIAN. (AMER. MUS. NAT. HIST.)

This experiment was of value in showing the deficiencies of the Peruvian method of embalming and the inferiority of such a process to the natural one to which the various sun-dried remains studied had been exposed. The specimen was the head of a young man, evidently between eighteen and twenty years of age, and probably of high rank, as shown by the gold beads about his neck and by the extreme care with which his body had been embalmed. The mouth cavity was well-filled with cotton from which the seed had been for the most part removed; his neck was wound around with several layers of cotton cloth, the inner strip of which was tied in a simple knot, and there seemed to be a large circular patch of some red pigment upon either cheek. His very abundant hair was wavy and flowing, and originally came about to his shoulders. The nose and the ears were present, although flattened and dried, and the skin of the face showed no dark patches indicative of decay, although the surface was cracked in several places, a circumstance which produced much difficulty in the attempt at restoration. In short, the general appearance was so good and the features so complete that we entertained great hope of a very satisfactory restoration.

In beginning the treatment, the hair was first carefully removed with shears, and the head immersed for a few minutes in water until the surface was well moistened, after which it was placed in a weak solution of caustic potash, not over 1 percent. Within a few minutes after immersion in the potash, the failure of this case became apparent. The two edges of the skin bordering each of the numerous cracks curled outward and revealed rapidly increasing areas of bare bone, and patches of skin cut off from the rest by cracks separated completely and floated away. It became evident that the embalmer's art had but arrested decay upon the surface alone and that nearly everywhere all structures between the integument and the surface of the bone, including the periosteum, had long since completely disappeared. The total absence of the ligaments was seen by the spontaneous separation of the cervical vertebræ from one another, and, as the process continued, the lower jaw, when free from its confining integument, became also separated from the skull, not a trace of ligament remaining to fasten it to the head. When the process was complete, the skull had lost neck, jaw, and the integument of the entire face as far up as the eyes, including the ears laterally, that of the eyebrows, forehead and scalp alone remaining, an area which corresponds to the region over which the integument lies directly upon the bone, and had probably dried without decay of the subcutaneous parts.

Noticeable features brought out by the treatment were (1) a raised scar extending along the right eyebrow, corresponding approximately to the superciliary ridge of the frontal bone, and (2) a small round bluish spot about 7 mm. in diameter, situated in the middle line of the forehead and possibly a tattoo mark.

Although disappointing from the standpoint of results, this experiment was extremely useful as a test of the Peruvian embalming process (or at least that used in this particular case) and in showing what we may expect in the case of this class of remains. If, as in this case, all ligaments and the soft parts intervening between the skin and the bone have disappeared, we can hope for little in the way of restoration except that of the integumental surface itself, or of the contour in case of regions where the soft parts readily admit of drying, as in the case of hands and feet. In the preparation of integumental surfaces for the better study of such points as tattoo-marks, scars, and skin diseases, the method may have a practical application even here.

5. ADULT MUMMIES OF THE "BASKET PEOPLE." (AMER. MUS. NAT. HIST.)

These consist of two adults, a man and a woman, the man without a head. They were obtained from a cave in southeastern Utah by the Hyde Expedition, and are referred by Professor Putnam to the "Basket-people, who seem to have occupied these caves earlier than the cliff-house people," but are considered by Dr Hrdlička to be identical with the latter, *i. e.*, "the prehistoric southern Utah Cliff-dwellers."[1] They had been evidently sun-dried, or, at least, air-dried under conditions that did not favor decay, probably those of a high mountain altitude, and had neither been embalmed in any way nor had the most ordinary care been taken of the bodies, and they had dried in apparently the positions assumed at death. The man lay on his back, with his knees strongly flexed and turned toward the right side, suggesting that they had been drawn up at death and had fallen to one side during the softening process of incipient decay. The woman was in a half-sitting posture, with knees semi-flexed, but at different angles, and with the toes drawn back by an extreme tension of the extensors. In both the position in which they had lain relative to the surface of the earth was very apparent, as those surfaces which had lain uppermost were very hard and white and showed no decay, while the lower surfaces were darker in color and had decayed sufficiently in some places to expose the bones. Thus in the man the dorsal surface of the sacrum was entirely bare and the coccyx readily removable. Aside from these lower surfaces there were a few places that exhibited the dark-brown color suggestive of decay, and in some other localities, *e. g.*, along the arms of the woman, the soft parts had suffered somewhat from the ravages of worms or from mechanical injury, thus exposing the bones.

Description fails, however, to give an adequate idea of the lightness and dryness of these remains. Although no tests were applied, the specific gravity must have been considerably less than that of cork, and in defective places, as along the arms of the woman, the parts splintered and crumbled almost at touch. The man had evidently been tall and large during life, but in his present condition he could be carried with ease by one hand at arm's length, and could not have weighed more than 12–15 pounds. Pieces of skin that cracked off in places, and which, when restored, had a thickness of 5–7 mm., measured about 1 mm. on an average and were hardly distinguishable from pieces of the inner bark of trees. When placed in water, an arm or a leg would lie upon the surface, repelling the liquid, and it was with some difficulty that they could be at first forced beneath the surface.

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[1] Quoted from personal letters from the authorities named.

For the treatment of these mummies I had two tanks constructed of galvanized iron, and supplied with flowing water by means of iron piping and siphons of rubber tubing. These tanks had a depth of 20 cm. and a width of 45.5 cm., and one of these was 76 cm. and the other 59 cm. in length. In conducting the experiments, which occupied the greater part of the winter, the mummies were dismembered in accordance with convenience, and the parts successively subjected to treatment, beginning with those parts which were of lesser value. As the details of this series of experiments would prove too laborious to record, and certainly too tedious to read, the matter may be considered under the three general topics of (*a*) the limbs, (*b*) the trunks, including the internal organs, and (*c*) the head and bust of the woman.

(*a*) *The limbs.* — Perhaps the most instructive observation obtained from these was that the muscles, when not decayed, showed a greater tendency to swell than did the integument, and that the extreme and long-continued drying to which this latter had been subjected through several centuries, prevented its expansion to quite its original condition. This was, of course, less noticeable over such parts as the feet or the dorsum of the hands where the bones lay in a superficial position; but upon such a place as the fleshy ventral side of the forearm, where the muscles would naturally round out the part and present a convex surface, the hampering effect of the tight integument was easily apparent. Especially in places where the integument was cut through, or along the edge of the limbs, where they had been severed from the body, could this effect be seen, as in such places the muscles were allowed to escape from their confines and swelled out to what was probably their original size. Such muscles were of an amber color and far more transparent than when fresh, yet consisted of bundles of fibers, which showed the characteristic appearance under the microscope, although lacking all trace of striation.

Portions of large girth, with a large proportion of soft parts, like the thighs, did not produce good results. In most cases these parts showed enough decay to prevent complete restoration, and even when this was not especially apparent, there was not sufficient rigidity in the soft parts to fill up the contours suggested by the skin. The limbs from knee or elbow down, were, for the greater part, well restored, although in such places as fore-arm, calf, or the thenar and hypothenar eminences of the hand, the integument was usually too rigid to admit of full expansion. The epidermic ridges of the surface of the palms and soles were very evident and we were able to trace out the complete patterns, although, as a matter of fact, the entire epidermis must have been wanting and what we really saw was the mold or cast of these ridges upon the surface of the cutis.

The best general results obtained were those of the right arm and hand, the left leg and foot of the woman, and the right foot of the man. From these it could be seen that both hands and feet were extremely narrow and the arch of the latter very high. The woman had been evidently of middle size, and had borne children (see below), but her foot was of about the size of that of a little girl of seven or eight of our race, although narrower than is usual with us.

These deductions cannot in this case be due to a deficiency in the swelling out of the tissues, since the proportions depend mainly upon the bones and very little upon soft parts other than the integument the normal thickness of which had evidently been regained. On restoring the woman's left hand it was found that the thumb, which was pushed between the index and middle fingers, held between it and the first joint of the latter a flat and rather soft object, the nature of which could not be made out, but which seemed of vegetable origin. Whether this object has any bearing upon the customs of these people I cannot say, but the entire hand was clenched and the object appeared as if intentionally though awkwardly held.

(*b*) *The trunks, including the internal organs.* — These were treated in the larger tank after the separation of the limbs, and were not as satisfactory regarding reëstablishment of the original contour as were the other parts, but furnished very interesting studies of the internal parts. In all cases the integument with its characteristic markings becomes quite normal of appearance and in a few points deserves some little notice.

The entire back of the woman, when treated, was marked with a conspicuous cross-striping which extended from the neck to sacrum and from side to side. This consists of bands of smooth dark skin of about 5 mm. in width and placed parallel to one another at regular intervals, leaving interspaces of perhaps 7 mm. At first we thought of a tattoo, but its extreme regularity as well as its location suggested the former presence of something woven upon which she had originally lain, probably a mat, the cross-weaves of which had protected the surfaces with which they had come in contact, allowing the erosion to continue between them. Microscopic examination corroborates this conclusion, since the stripes give evidence of a far better preserved condition of the cutis than is shown by the more spongy interspaces.

As for tattooing, certain dark stripes upon the man, one placed lengthwise on one shoulder, another in the midline of the abdomen from umbilicus to pubis, may possibly be referred to this head, but a far more obvious example is that upon the other shoulder, which consists of a series of heavy black oblique lines ranging from 5–8 mm. in width, crossed by a second set of oblique lines in the opposite direction. If this be a tattoo, it is of very crude workmanship; the lines show no regularity in width, and are irregularly placed. Aside from the above, the forehead of the woman, before it was subjected to treatment, showed five or six lines in consecutive circles, the lines being themselves composed of separate oval dots, but the arrangement of the entire design was asymmetrical, the center being near the inner corner of the right eye. Since no trace of this was left after the treatment, it was probably a paint or marking left by some article of clothing.

Both trunks after brief immersion in the potash (one-half to one hour) admitted of a thorough and very satisfactory dissection; the organs were found for the most part well preserved, but dried to the consistency of thin membranes, incapable of further restoration, undoubtedly because the connective tissue elements alone were left. Thus the intestines, the mesenteries with their blood vessels, and even the omentum were easily distinguishable and were with some care separated from one another, but the heart was reduced to a shrunken mass of membrane representing the pericardium, the valves, etc., and all that could be found of the liver were the numerous branches of the blood-vessels and bile ducts, the latter observation especially emphasizing the fact of the loss of all epithelial tissues. In the stomach both muscular and serous coats were well preserved, and separated from each other almost spontaneously ; but in both cases the stomach, although normally inflated, was either completely or almost empty, that of the woman yielding three melon seeds and a single piece of some stringy substance which we have been unable to identify. Several masses of fecal matter were found in the intestines of the woman, which, when examined with the microscope, yielded nothing but a few bits of vegetable tissue. In both cases the appendix was normal and well developed. The lungs, corresponding to their large connective tissue constituent, were well preserved, and in a few places had imprisoned a little air in drying. They showed both by their color and under the microscope carbonization to about the same degree as in the modern white race.

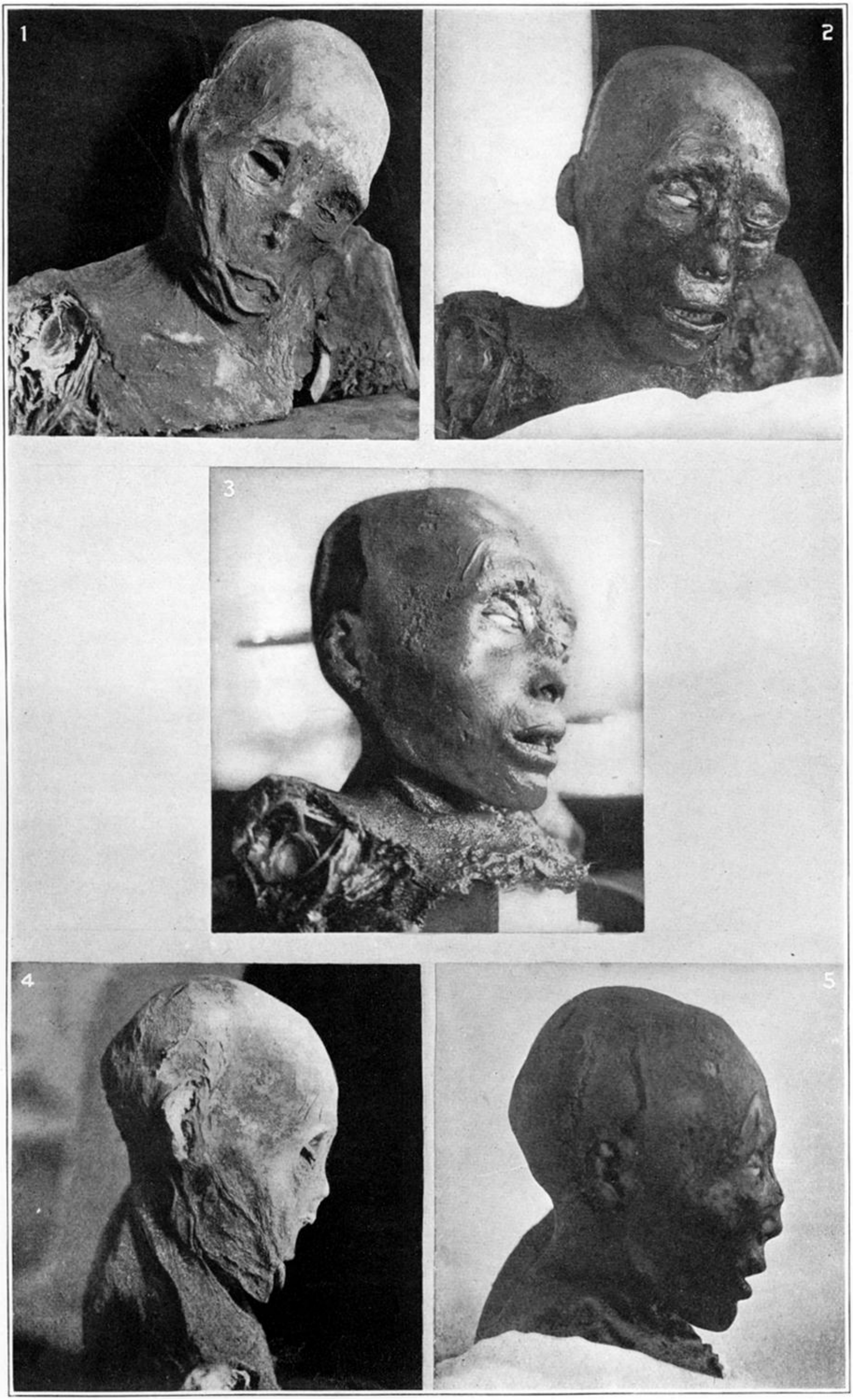
The kidneys were reduced to thin wafers, consisting evidently of the pressed and dried tubules of the medulla, and to these were attached the ureters, connected with well-preserved urinary bladders. The uterus of the woman was slightly asymmetrical, being deflected toward the left side, and as the distance between it and the left ovary was far less than between it and the right one, it is probable that this lateral displacement had been present during life, and was not due to the effect of gravitation acting upon the organ after death. The shape of the os uteri externum indicated that she had borne children, a supposition in accordance with the condition of the mammæ, which was shown by the integument, although the glandular portion, being epithelial, had long since disappeared. In the man the appearance of the genitals did not indicate circumcision, although the prepuce had become very thin and the free edge of the fold was ragged and worn.

(*c*) *The head and bust of the woman.* — As this piece presents the most general interest, both in itself and as a test of the method used, we took several photographs of it both before and after treatment, the presentation of which (pl. II) will almost obviate the necessity of further explanation. The separation from the body was made just below the arm-pits, in order to preserve the contour of the neck and shoulders and the relation of the head to the trunk. In the dried state the head was bent strongly to the left, as though it had fallen over by the force of gravity before it became stiffened by the process of desiccation, and it is interesting to note that this defect became in great measure remedied by the treatment through the natural elasticity of the parts, although no especial attempt was made to straighten it. The same may be observed in the case of the lower lip, which had fallen down and dried in that position and which came up of its own accord by the restoration. The dropping of the jaw, however, perhaps because dependent upon ligaments and other internal parts, was not completely remedied, although much improved, and the separation of the lips in the restored specimen is due to this rather than to any defect in the lips themselves (see especially fig. 3). The left eyelid came well into shape and remains closed, while the right is partly open, and as the eyeball of this side was somewhat deficient, the socket was filled out with absorbent cotton, which is the white mass showing in the photograph. The left eyeball is quite full, although somewhat wrinkled, and shows a good iris and pupil when the lid is raised. The cartilaginous portion of the nose is, unfortunately, not wholly restored, since, when the head had attained its present condition, some of the softer parts threatened to fall to pieces, and in order to prevent this the entire head was put in three-percent formalin over night. This hardened the entire specimen and rendered the skin so firm and immovable that all subsequent treatment was of no avail. The method of continuing the action of the potash over certain areas alone, as suggested above, occurred to us too late, and although we worked for several days over the nose, there was little if any later improvement. I am persuaded, however, that if the formalin had not been used at that time, and if the potash had still been applied to the nose while the other parts were wrapped in wet cotton as recommended above, the result would have been better; but a comparison of the photographs of the dried and of the restored face will show a great improvement in the feature under discussion, even though it has failed to attain its original proportions. The elasticity shown in the lips and neck appears also in the case of the ears, as a comparison of the two sets of photographs will show.

Upon the right side of the head, above the ear, is a rather extensive oblong area from which the scalp had been removed, showing the bone (pl. II, 3, 5). As this was the condition in the dried specimen, although hardly distinguishable owing to the uniform color of this and the rest (pl. II, 4), it suggests that this piece had been removed before the body had dried, but for what purpose we can only conjecture. In pl. II, 4, 5, there will also be observed a curious scar at about the top of the head, which consists of a deep indentation of the bone lined by the skin and is undoubtedly the result of an injury received earlier in life.

Except in the most sheltered portion of the back of the neck there was no trace of hair, and this, taken in conjunction with a few other observations, gives a singular conclusion. In the first place the absence of hair is correlated with the total absence of nails from both fingers and toes, although the nail beds are so perfect that this absence is scarcely noticeable. Then, in draining off the tanks after the operation, there was left a considerable quantity of a brick-red deposit, which dried into a coarse powder and showed itself under the microscope to be dune sand, little irregular nodules of reddish quartz, which, although not noticeable in the dried specimens, must have filtered into every crevice and have become dislodged by the washing and soaking. This dune sand may perhaps furnish the clue to the absence of nails and hair, and suggests that they have been worn off by the triturating effect of the wind-blown sand.

Another phenomenon, and one which is less easy to explain, has been the discovery of countless specimens of a small species of mite (*Acarina*), first found upon the stomach-contents of the woman, and later, in still greater quantity, within the uterus and in the nasal cavities. In the latter places, small reddish particles, which detached themselves from the walls, resolved themselves into masses of mites, some entire and others in fragments, mixed with blood corpuscles. Here the simplest supposition is that, being troglodytic animals, they have used the dried mummies for their habitat in the same



HEAD OF WOMAN MUMMY OF THE "BASKET PEOPLE" (CLIFF-DWELLERS)
1 and 4, In dried condition. 2, 3, and 5, After restoration. (Photographed from the object.)

way as they would use a fallen tree-trunk, and that they have found their way to all accessible cavities of the body, although their association with blood corpuscles might indicate either a parasitic habit, or that they infested the body soon after death.

Much can certainly be obtained from further microscopic investigation of softened mummied material, but not only is a thorough knowledge of botany, zoölogy, anatomy, and histology necessary, but an acquaintance with the ethnology of the people to be studied, including their manners, customs, and religious rites, in order to intelligently direct such investigations. This work can best be done then by the collaboration of several investigators, and it may be hoped that something will be done in this line in the near future.

As far, also, as the gross application of the softening and restoring method is concerned, my investigations thus far have not covered the field or exhausted the possibilities of the method, since the various forms of Egyptian mummies have not yet been tested, nor has the investigation of the Peruvians been by any means completed. It may not be too much to suggest, if the method is found applicable to the best embalmed mummies of the Egyptians, that at some future time the faces of the great Pharoahs may be seen in a still more life-like condition than that which they exhibit at present in the glass cases of the Gizeh Museum.